Is the Niño-3.4 region optimal for monitoring ENSO and its impacts on North America?

Michelle L'Heureux, CPC
Anthony Barnston, IRI
Michael Tippett, IRI

38th Climate Diagnostics and Prediction Workshop
College Park, MD

Due to the Federal government shutdown, NOAA.gov and most associated web sites are unavailable.

Specific NOAA web sites necessary to protect lives and property are operational and will be maintained.

See Weather.gov for critical weather information or contact USA.gov for more information about the shutdown.

NOAA Federal Employees: For access to the Notice to Federal Employees About Unemployment Insurance (SF-8), please Click Here.

An Operational Monitoring Goal:

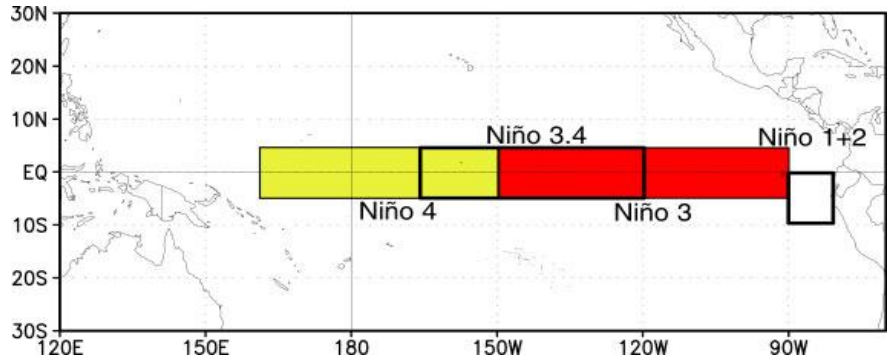
Desire a keystone index that is relatively simple to calculate, by various user groups, that best captures the El Niño-Southern Oscillation (ENSO), a coupled ocean-atmosphere phenomenon in the tropical Pacific Ocean.

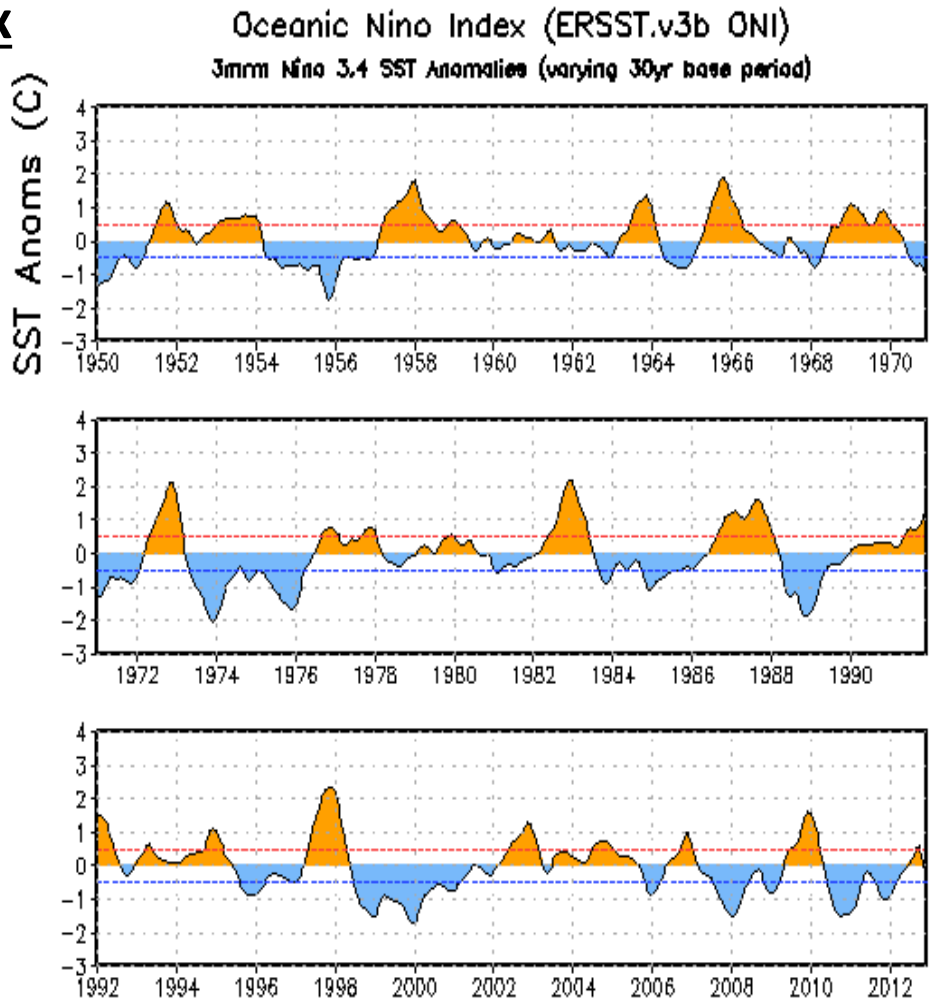
Ideally, this index would also ic
relationships with seasonal ter
precipitation for all seasons ov

NOT Keystone Cops

Current Operational ENSO index in use at CPC/IRI

<u>Niño-3.4 Index</u> or <u>Oceanic Niño Index</u> (ONI), which is based on 3-month running averages in Niño-3.4





Barnston, Chelliah, and Goldenberg (1997) documented the Niño-3.4 SST region based on its strong relationship with sea level pressure and subsurface temperatures.

Kousky and Higgins (2007) document the Oceanic Niño Index (ONI), which is in operational use today.

This monitoring goal does not supersede the need and desire for other complimentary indices that provide information on other aspects of ENSO.

Includes:

-- different SST regions across the Pacific Ocean

-- the Southern Oscillation Index (SOI)

-- Outgoing Longwave Radiation (OLR) and wind-based indices

-- the Multivariate ENSO Index (MEI)

-- the growing set of "ENSO flavor" indices (e.g. Modoki, Central Pacific (CP) vs. Eastern Pacific (EP) El Niños)

Questions Asked:

(1) Which regions of SST and OLR best capture ENSO ocean/atmosphere coupling? Character of these relationships?
(2) How to optimally combine OLR with Niño3.4 to measure impacts?
(3) Combined Central Pacific (CP) OLR - Niño-3.4 index versus Niño-3.4 only influence on N. American T&P?
(4) Does the Eastern Pacific (EP)-OLR index provide improvement over using CP-OLR?

Data Used:

3-month (seasonal) overlapping averages from 1982- 2012:

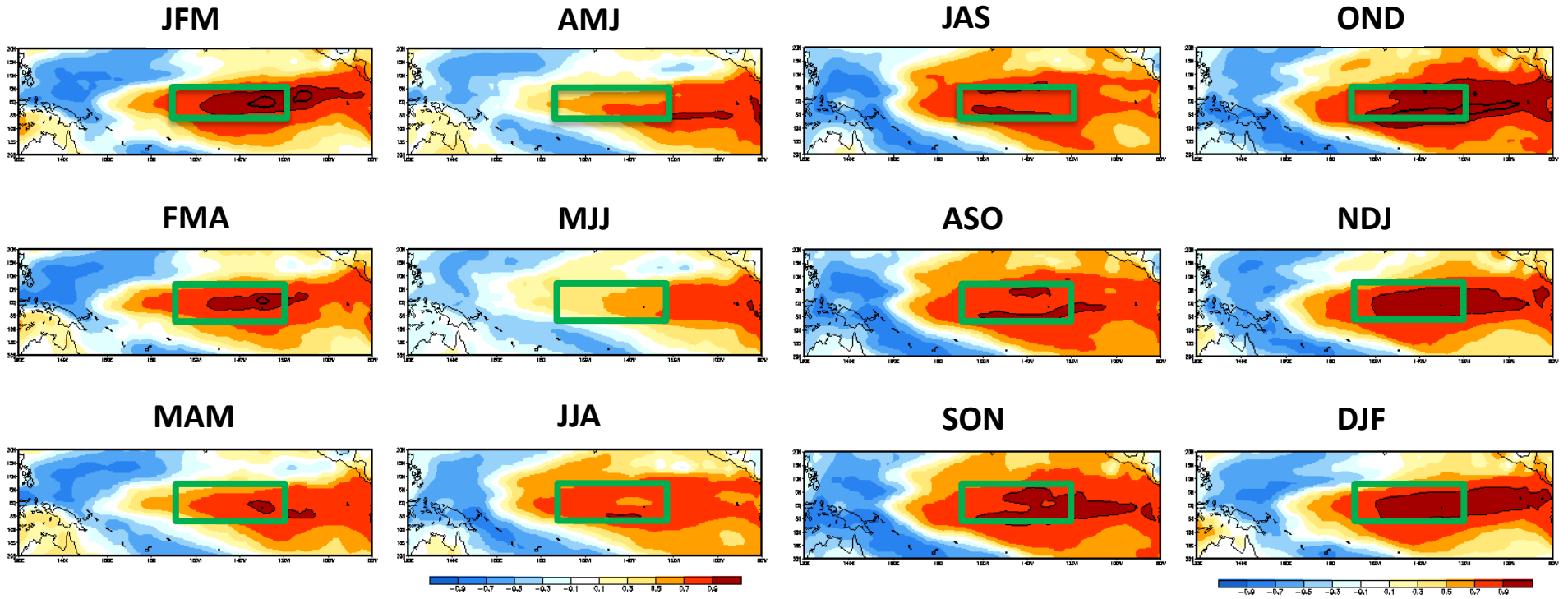
- OISST.v2 and NOAA/CDC OLR
- 0.5°x0.5° gridded CPC Unified gauge-based Precipitation
- 0.5°x0.5° gridded GHCN-CAMS Temperature

[note: station coverage over most of Canada is poor]

Which Pacific regions maximizes coupling between OLR - SST?

Canonical Correlation Analysis (CCA) between SST and OLR anomalies by season

Leading SST Pattern

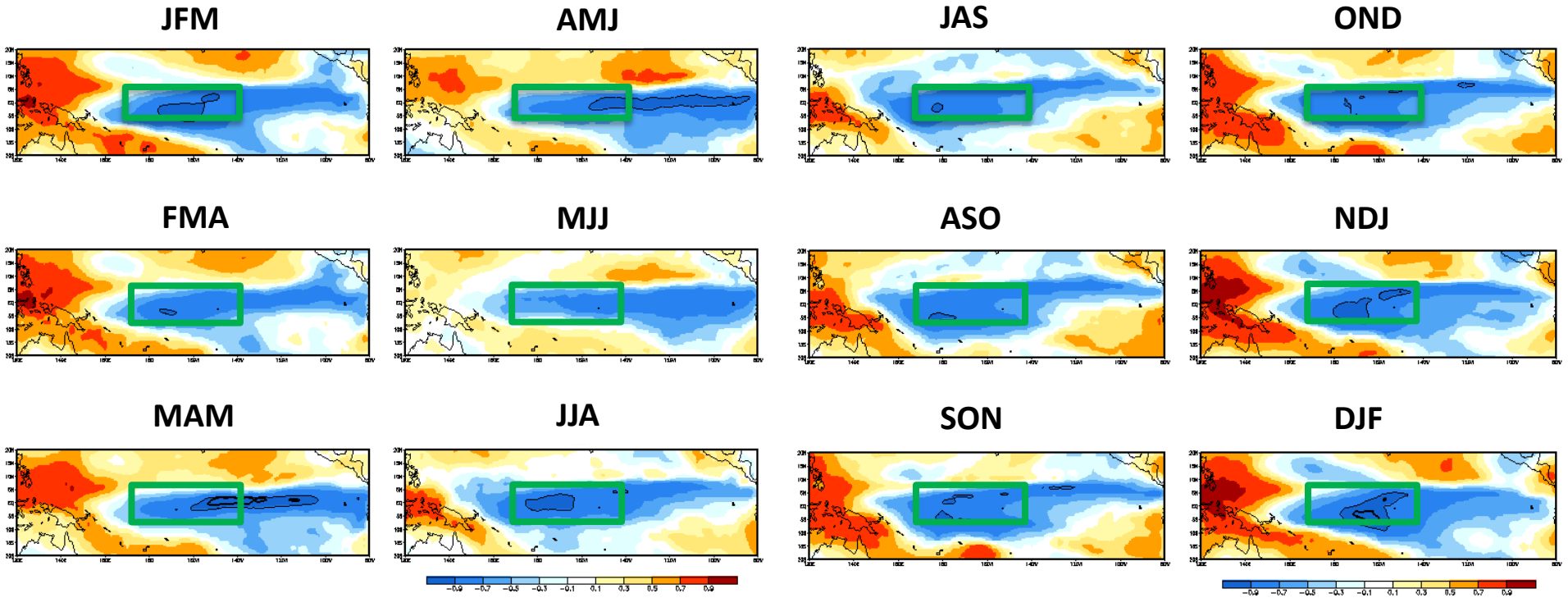


The Niño-3.4 region (170°W-120°W: green box) contains strongest correlations with OLR, except during springtime (~AMJ-MJJ)

Which Pacific regions maximizes coupling between OLR - SST?

Canonical Correlation Analysis (CCA) between SST and OLR anomalies by season

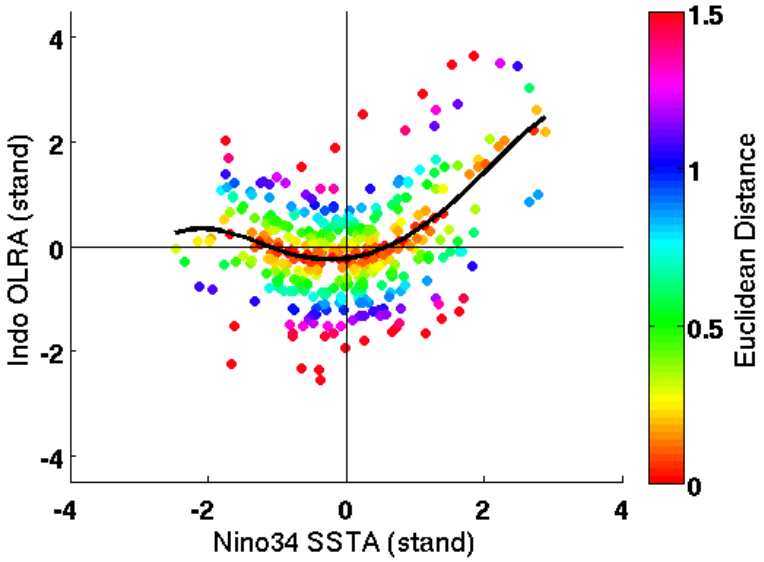
Leading OLR Pattern



The Central Pacific (CP) OLR region (170°E-140°W: green box) contains strongest correlations with SST, except during springtime (~AMJ-MJJ)

Characteristics of regional OLR-Niño3.4 relationship?

"Indonesia" (120E-170E)

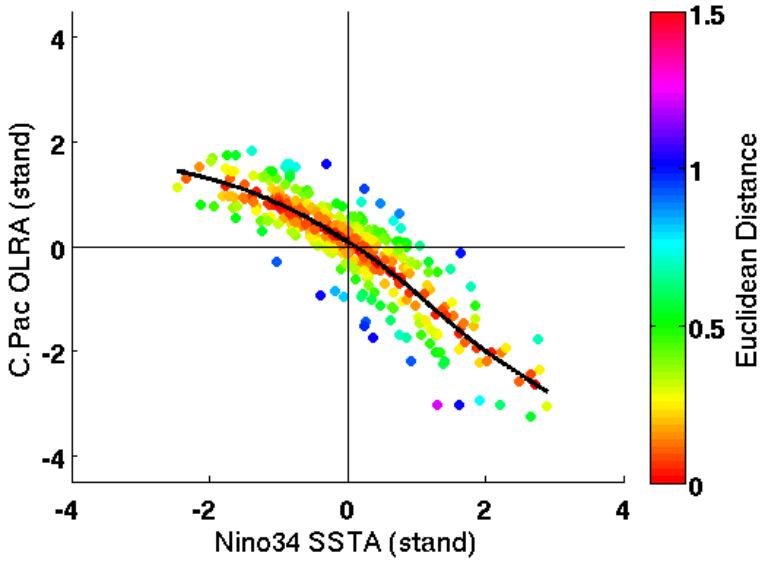


Each dot represents a single month.

Black line: Local linear Regression

Dot color: Distance from black line

"Central Pacific" (170E-140W)



- **Central Pacific (CP) OLR**: most linear with Niño-3.4 SSTs.
- Relative to Indonesia, CP OLR has less spread from the black fitted line.

- **East Pacific (EP) OLR**: asymmetry between positive and negative Niño-3.4 SST values.
- Large spread from the fitted line during springtime when local SSTs are typically warmest and elicits a larger OLR response.

How to optimally combine OLR with Niño3.4 to measure impacts on N. America?

Will evaluate three linear models:

"Climatology": $y = c$
"1-predictor Model": $y = b1\ x1 + c$
"2-predictor Model": $y = b1\ x1 + b2\ x2 + c$

Where, y is precipitation or temperature
x1 is Niño-3.4
x2 is OLR
c is the climatological average

A model with more parameters will always fit the data better, so want to whether the model significantly improves the fit to the data.

F-test will evaluate the reduction of the sum squared error.

For now, the focus on using CP-OLR index because region is typically coupled to Niño-3.4.

First, how to interpret the figure

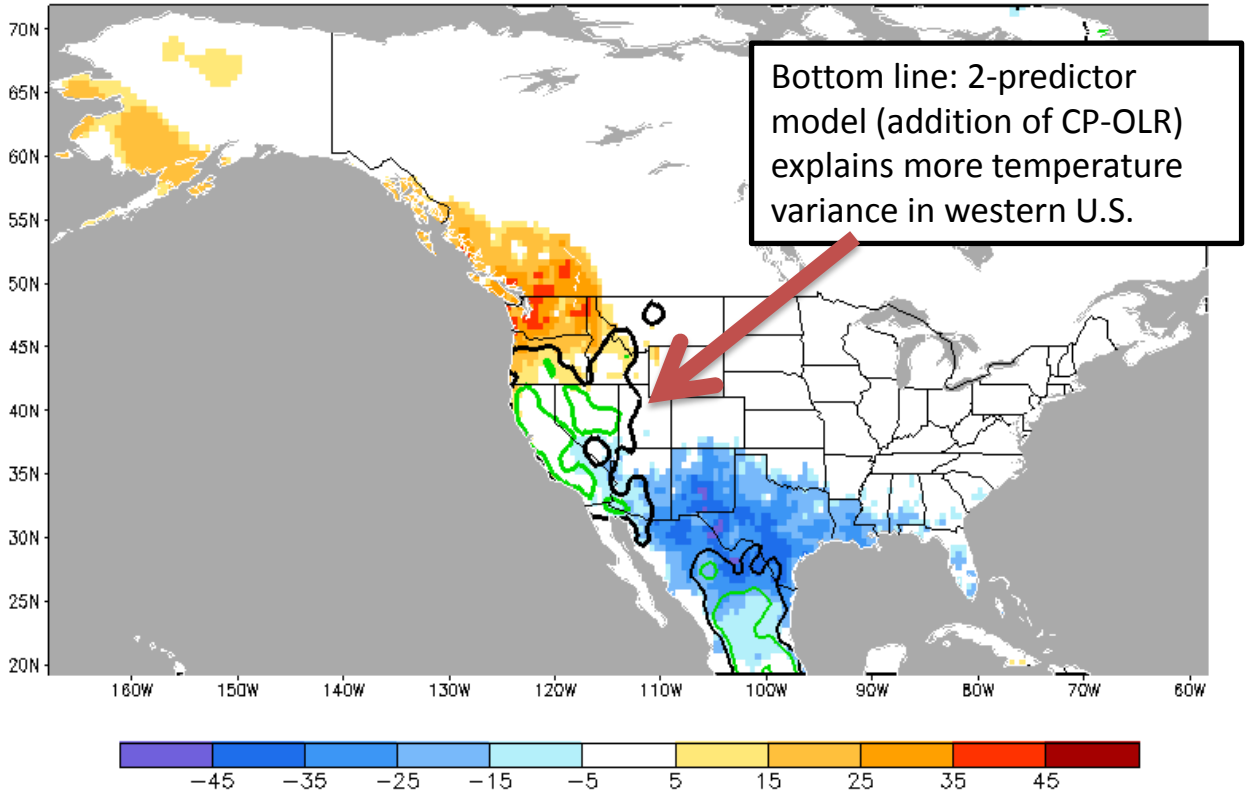
Shading: where 1-predictor model (Niño-3.4 only) does better than mean/intercept

Contours: where 2-predictor model does better (addition of CP-OLR)

Color bar / Contour level:
Explained variance of temperature described by the model (r^2x100)

Pos. or neg. values:
Sign of the regression coefficient

Mar.-May (MAM) Temperature



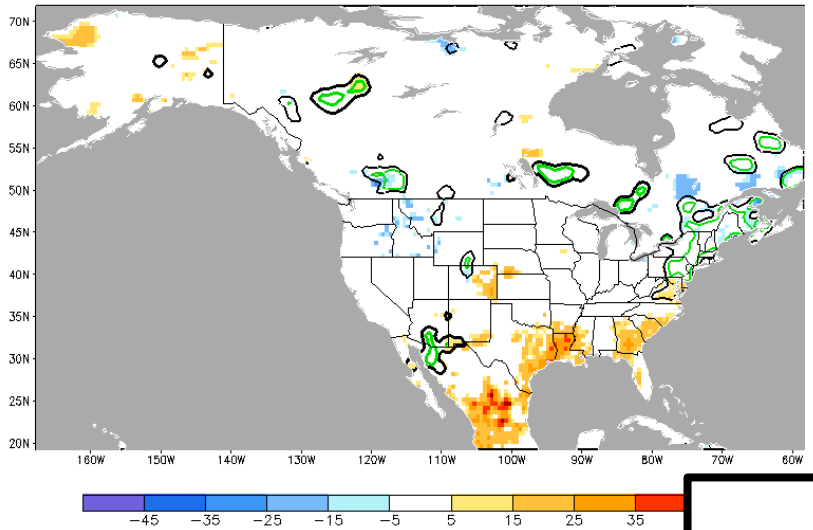
Impacts on N. American Precipitation Anomalies?

Shading: where 1-predictor model (Niño-3.4 only) does better than mean/intercept

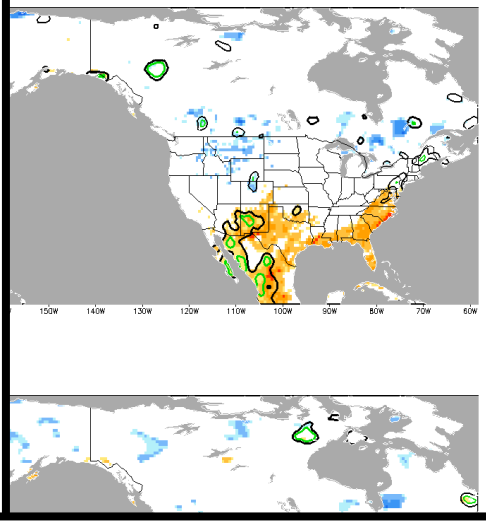
Contours: where 2-predictor model does better (addition of CP-OLR)

"Cold Season"
Addition of CP-OLR to Niño-3.4 does not significantly contribute to precipitation
--except during transition seasons (OND/MAM)

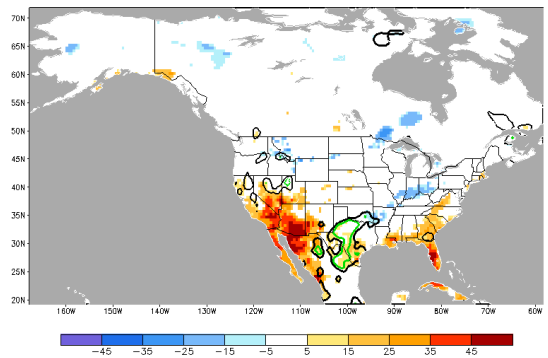
OND



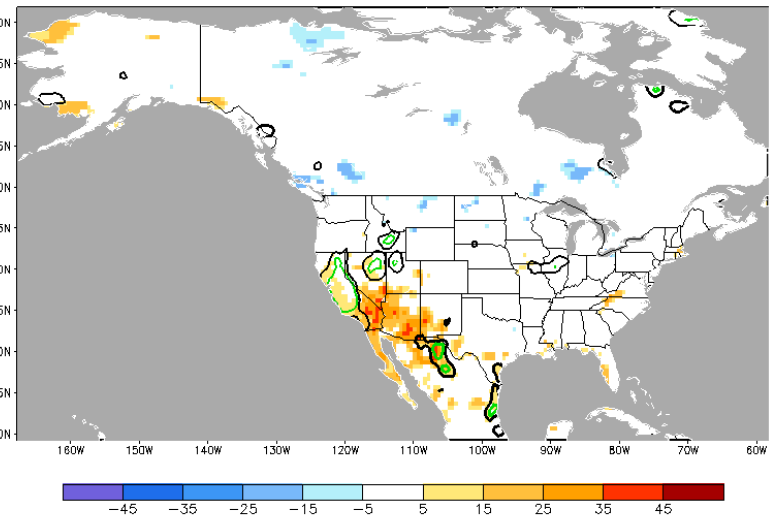
NDJ



FMA



MAM

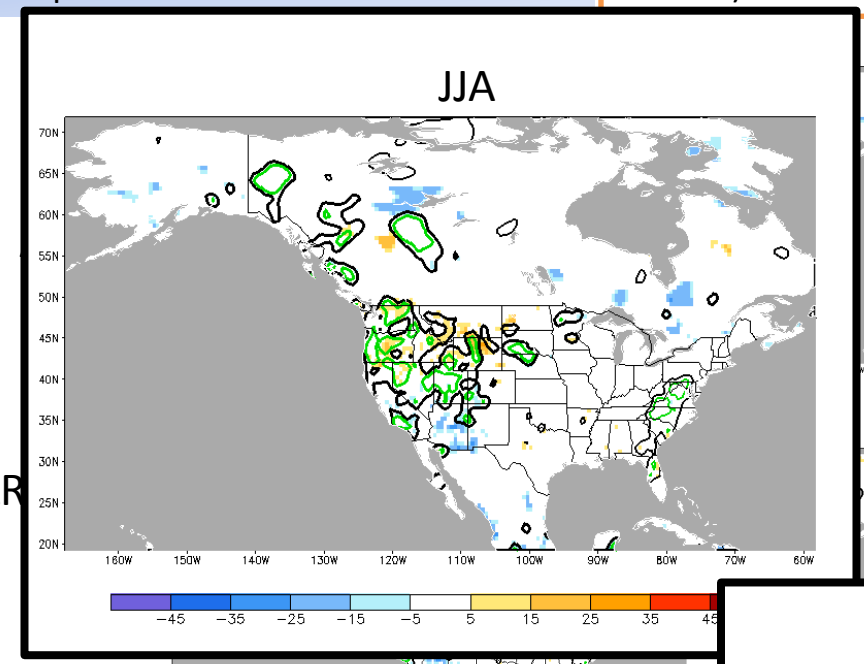


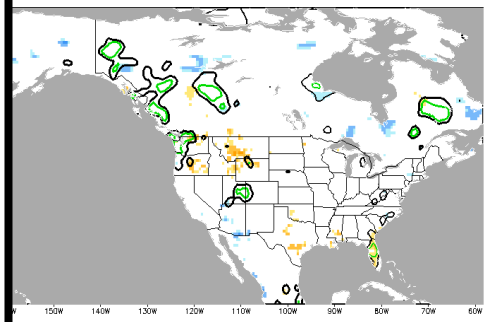
Impacts on N. American Precipitation Anomalies?

Shading: where 1-predictor model (Niño-3.4 only) does better than mean/intercept

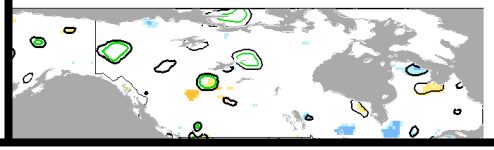
Contours: where 2-predictor model does better (addition of CP-OLR)

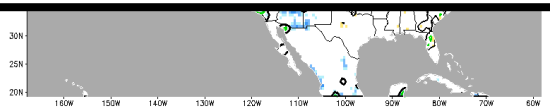
"Warm Season"
Addition of CP-OLR to Niño-3.4 significantly contributes to precipitation in JJA and JAS



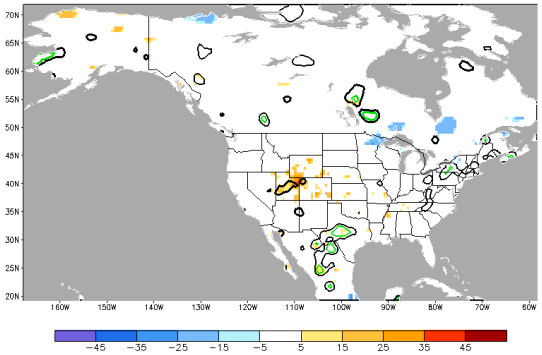


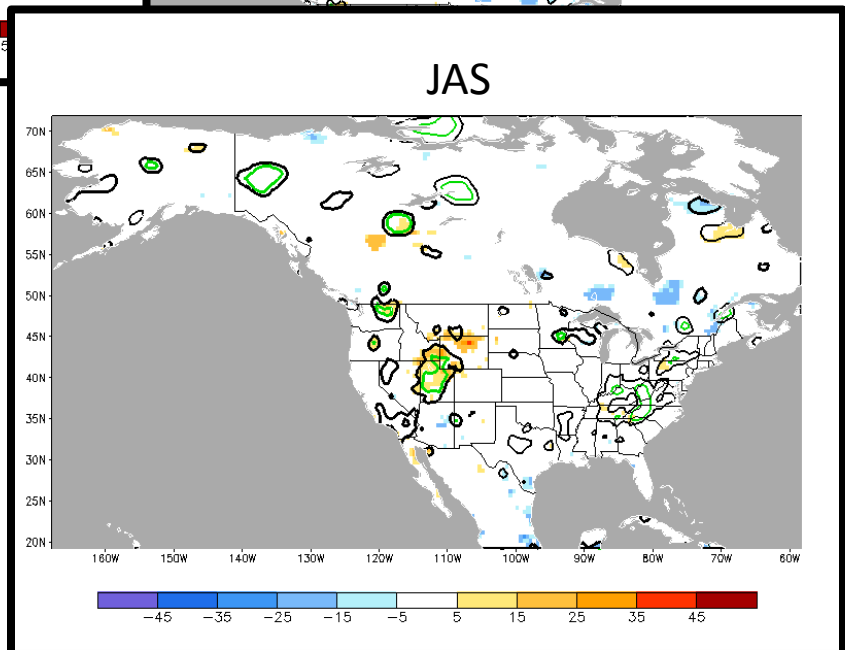
MJJ





ASO



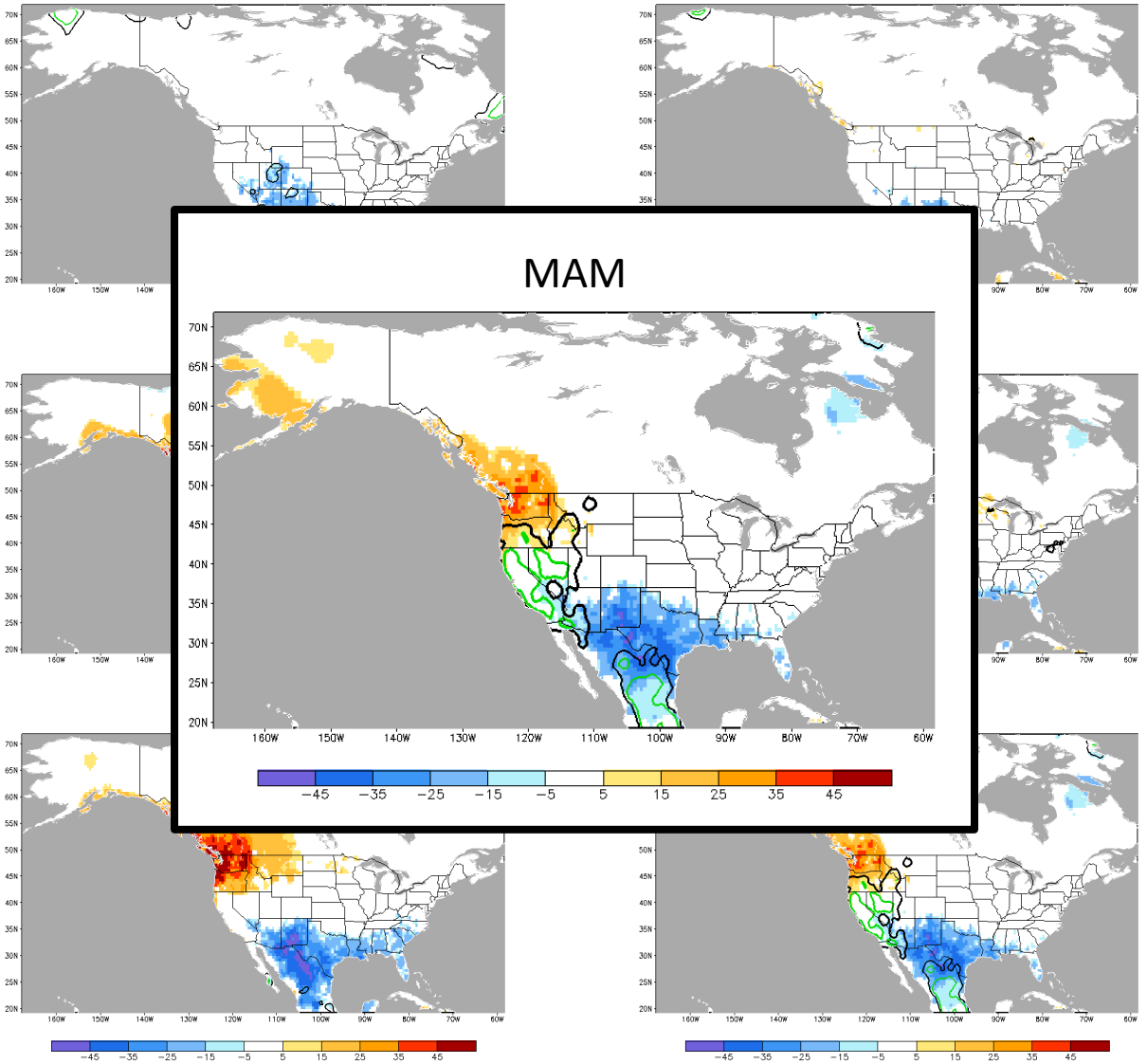


Impacts on N. American Temperature Anomalies?

Shading: where 1-predictor model (Niño-3.4 only) does better than mean/intercept

Contours: where 2-predictor model does better (addition of CP-OLR)

"Cold Season"
Addition of CP-OLR to Niño-3.4 does not significantly contribute to temperature
--except during spring MAM/AMJ

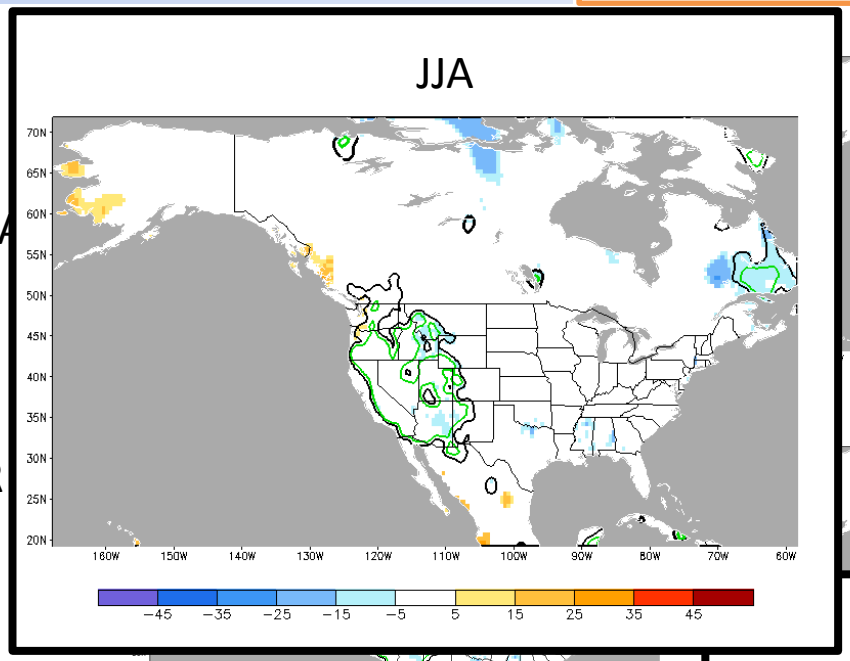


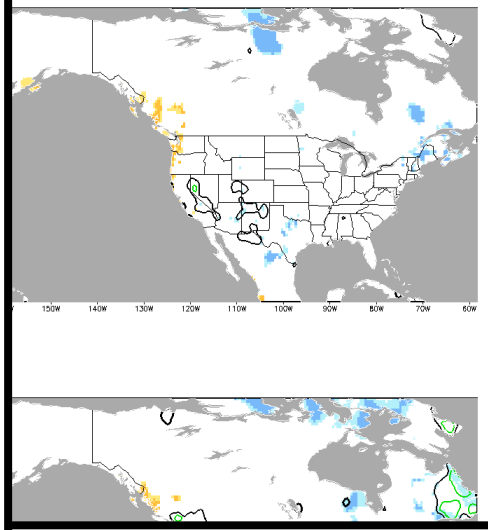
Impacts on N. American Temperature Anomalies?

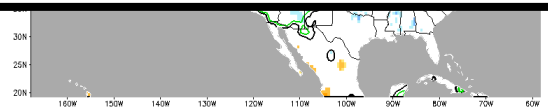
Shading: where 1-predictor model (Niño-3.4 only) does better than mean/intercept

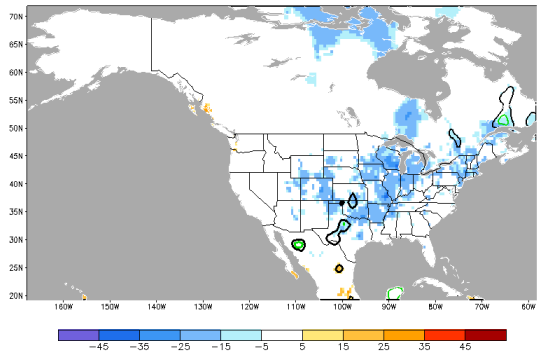
Contours: where 2-predictor model does better (addition of CP-OLR)

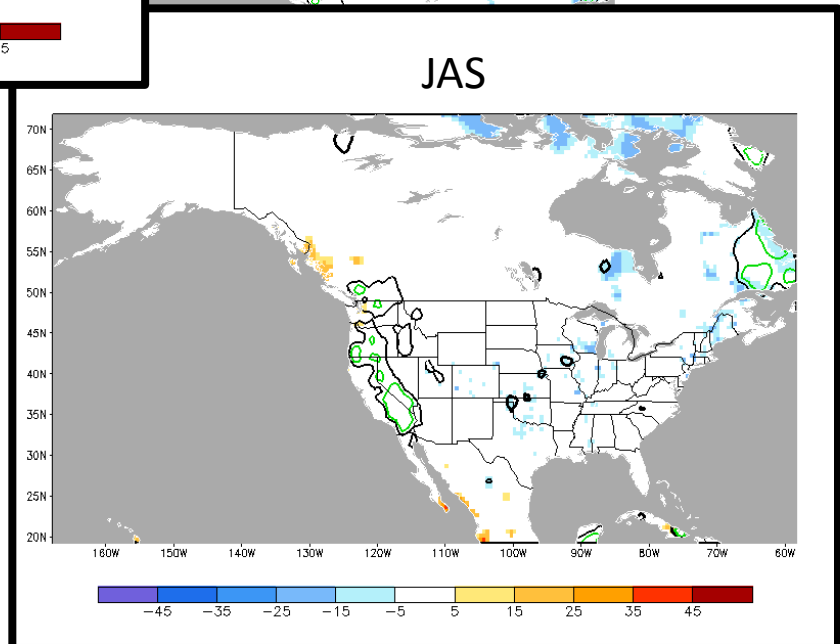
"Warm Season"
Addition of CP-OLR to Niño-3.4 significantly contributes to temperature in JJA and JAS









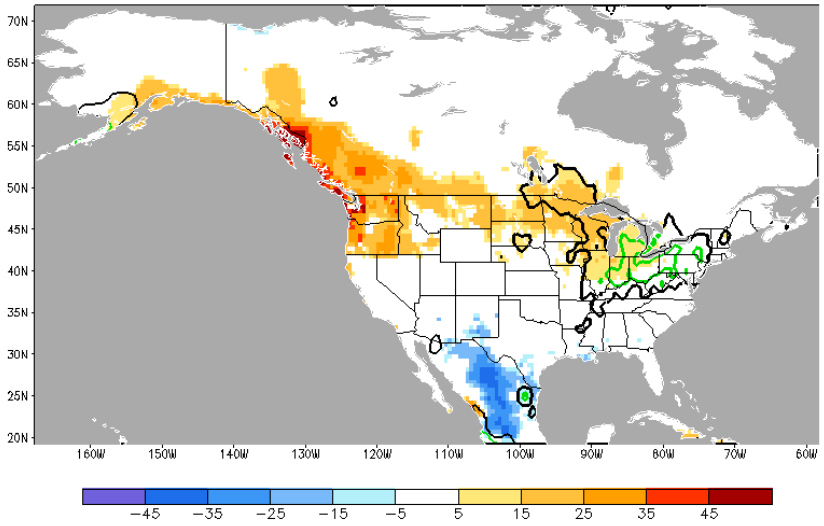


Does using EP-OLR index provide an improvement over using CP-OLR?

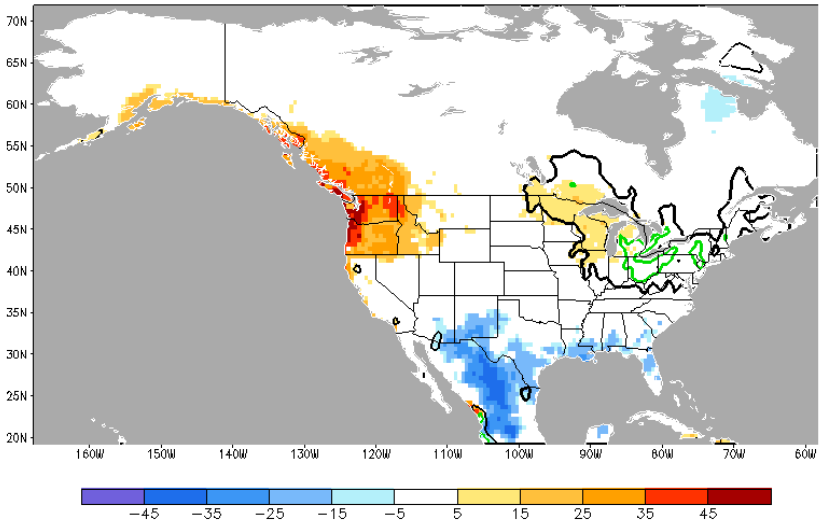
Overall, no. Difference maps indicate that the combined index of CP-OLR+Niño-3.4 explains more variance than EP-OLR+Niño3.4.

One clear exception: During wintertime, EP-OLR+Niño3.4 explains more temperature variance over the Northeastern U.S.

DJF temperature



JFM temperature

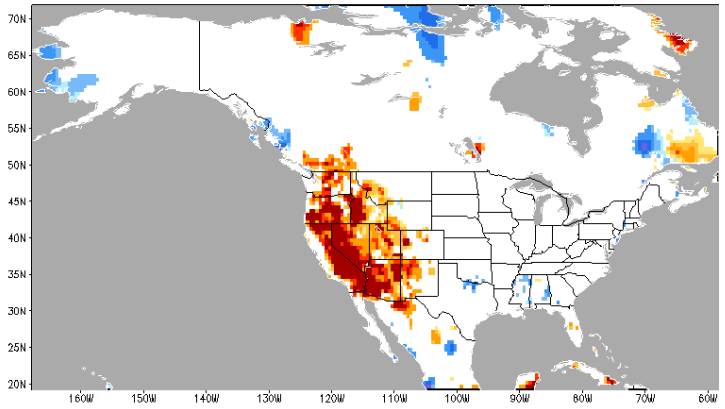


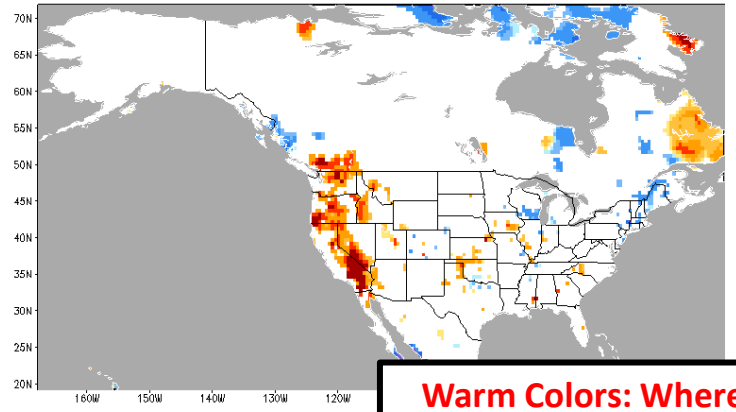
Can we simplify using equal weighted CP-OLR and Niño-3.4 index?

Yes. Using equal weighted predictors (CP-OLR + Niño3.4) represents an improvement over using Niño-3.4 only. Something to consider in the summer?

Temperature

JJA



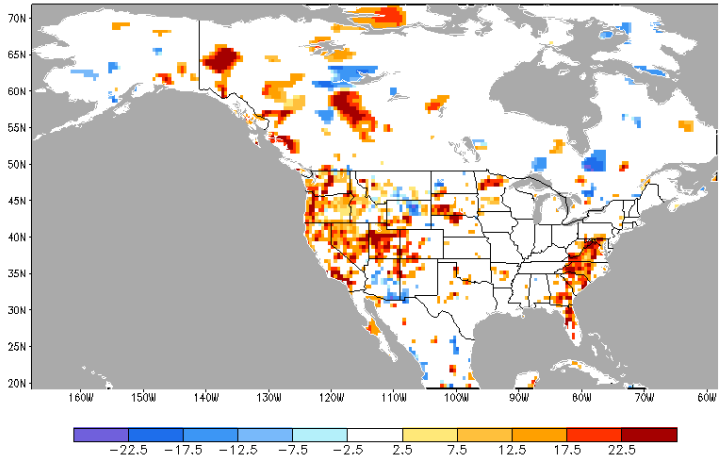


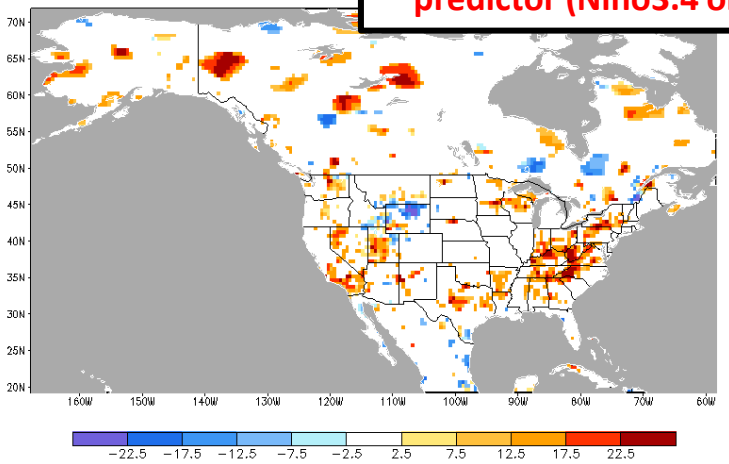
JAS

Warm Colors: Where % Variance Explained is higher relative to 1-predictor (Niño3.4 only) model

Precipitation

JJA





JAS

Operational Monitoring Goal:

Desire a keystone index that is relatively simple to calculate, by various user groups, that best captures the El Niño-Southern Oscillation (ENSO), a coupled ocean-atmosphere phenomenon in the tropical Pacific Ocean.

Ideally, this index would also identify significant relationships with seasonal temperature and precipitation for all seasons over North America.

What can we conclude?

The Niño-3.4 SST index (ONI) alone is *good enough* for operational monitoring of ENSO.

-- simple to calculate
-- a region that is strongly correlated (coupled) with convection/OLR during all seasons
-- significant linear relationships with seasonal T&P over N. America during nearly all seasons

What are the gaps if using only Niño-3.4?

(1) Some regional and seasonal features may be resolved better with the addition of OLR:

-- summer (JJA and JAS) N. American T&P appears best captured with a **CP-OLR** + Niño-3.4 index.
-- spring (MAM) T&P over the western U.S. improved with **CP-OLR** + Niño-3.4 index
-- fall (OND) Precip. over northeastern U.S. bettered with **CP-OLR** + Niño-3.4 index
-- winter (DJF/JFM) Temp. over the northeastern U.S. improved with **EP-OLR** + Niño-3.4 index

(2) Analysis predicated on **linear** relationships. Unable to conceive a satisfying method to test significance of non-linear relationships given limited sample sizes in the ~30 year record.